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ANOMALIES IN THE DECAY OF PARTICULAR NUCLEAR ISOTOPES

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Final Report

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14. ABSTRACT

It is extremely challenging to measure the half-life of long lived isotopes. A USAFA-Purdue-Stanford- CCHEN collaboration has documented experiments in which small, unexplained fluctuations were found in the half-lives of select radioisotopes. Since the fluctuation was small in each case (on the order of 0.5%), the effect usually had only a relatively minor impact on the determination of the half-life. A comparison of the periodic behavior of the data from several of the experiments indicated that the periods of the primary mode of oscillation are remarkably similar. While the systematic effects are certainly possible, the group notes the anomalies are similar in nature to some experimental Dark Matter searches that may indicate new physics.
The group has gained access to daily calibration data for the IAEA's International Monitoring System. In a surprising turn of events, the group showed many of the IMS detectors are measuring small annual oscillations in many of the same isotopes as the aforementioned

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Nuclear Decay, Periodic Variations

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Precision Nuclear Decay Monitoring Experiment

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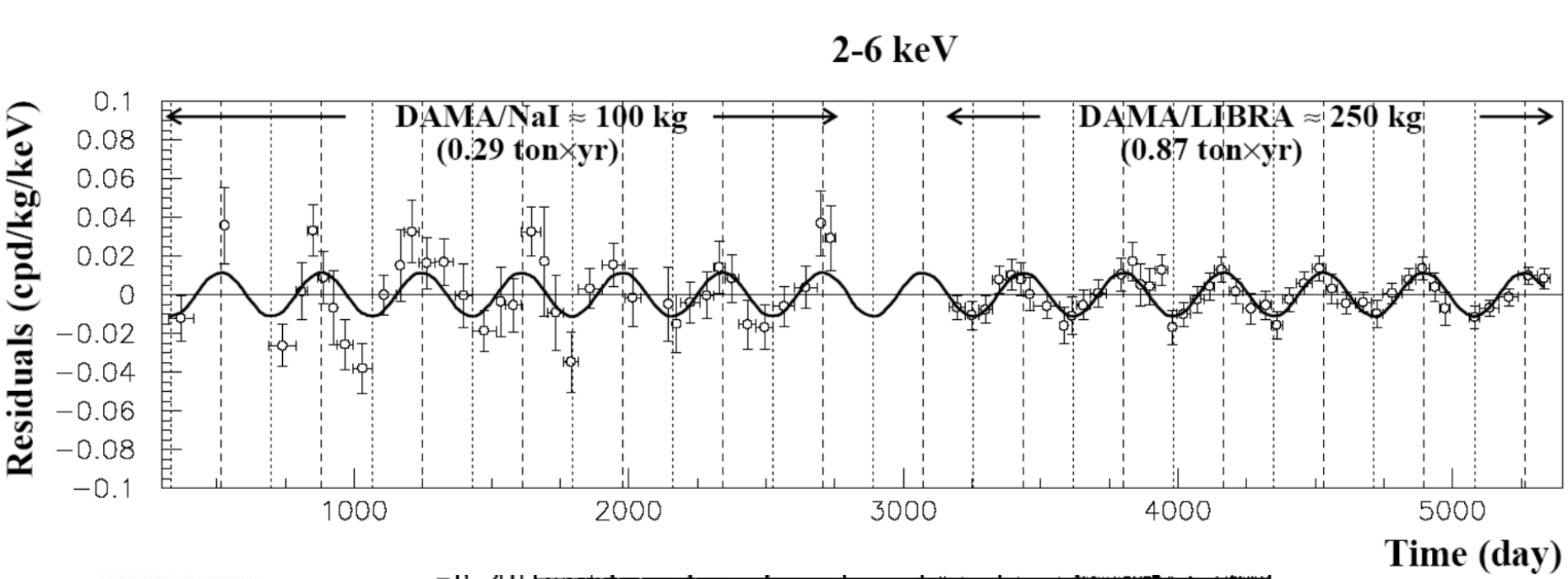
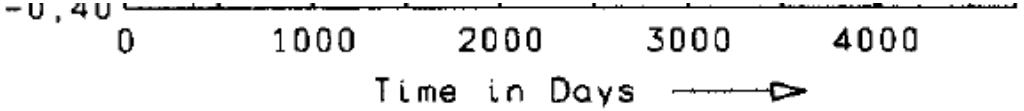
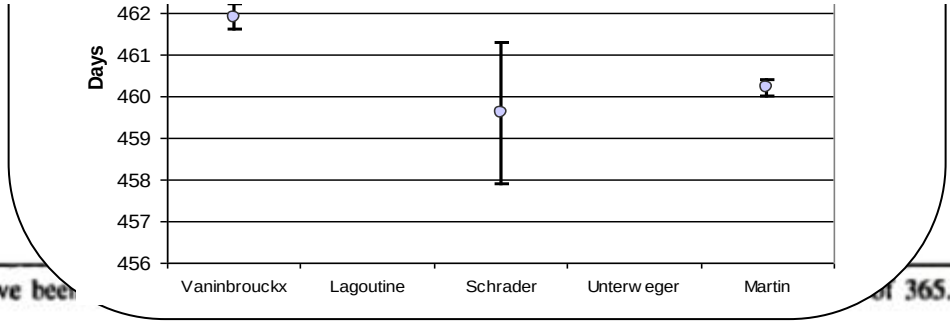
576 Nuclear Instruments and Methods in Physics Research A286 (1990) 576–583
North-Holland

THE HALF-LIFE OF ^{137}Cs – A CRITICAL REVIEW





Flynn et al. (a)		
Flynn et al. (b)		
Anspach et al.		
NBS		
Lagoutine et al.		No
Ramthun		No
Debertin		No
Kochin et al.		No
Schötzig et al.		Yes
Martin et al.		Yes
This work		Yes



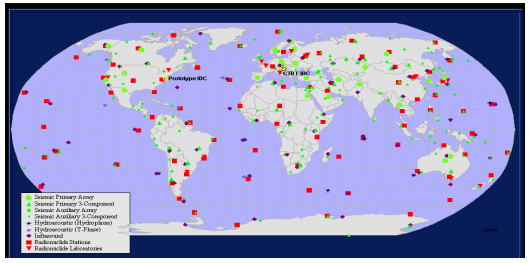
* Where published values have been ... of 365.25.

Measured Half-lives for ^{134}Cs and ^{109}Cd

CCHEN Decay Experiment: Unraveling Reports of Anomalous Decay

- **Periodic Variations Reported in 25 Long-term Nuclear Decay Experiments**
  - **Select β & E.C. Decay Affected**
  - **Wide variety of detectors types**
  - **Few experiments run for many years; independent confirmation difficult**

- **Periodic Variations found in IAEA's International Monitoring System (IMS) of precision radioisotope detectors**
  - **System monitors nuclear prolif**
  - **Anomalies confirmed in calibration sources across network**
  - **Matches some anomaly reports**



Isotope	Effect Observed
^{3}H	Periodicity: 1 yr^{-1}
^{3}H	Periodicity: 1/d, 12.1 yr^{-1}, 1 yr^{-1}
^{3}H	Periodicity: ~12.5 yr^{-1}
^{3}H	Periodicity: ~2 yr^{-1}
$^{22}Na/^{44}Ti$[a]	Periodicity: 1 yr^{-1}
^{36}Cl	Periodicity: 1 yr^{-1}, 11.7 yr^{-1}, 2.1 yr^{-1}
^{36}Cl	Periodicity: 1 yr^{-1}
^{54}Mn	Periodicity: 1 yr^{-1}
^{56}Mn	Periodicity: 1 yr^{-1}
^{60}Co	Periodicity: 1 yr^{-1}
^{60}Co	Periodicity: 1/d, 12.1 yr^{-1}
^{85}Kr	Periodicity: 1 yr^{-1}
$^{90}Sr/^{90}Y$	Periodicity: 1 yr^{-1}, 11.7 yr^{-1}
^{108m}Ag	Periodicity: 1 yr^{-1}
^{133}Ba	Periodicity: 1 yr^{-1}
^{137}Cs	Periodicity: 1 yr^{-1}
^{152}Eu	Periodicity: 1 yr^{-1}
^{152}Eu	Periodicity: 1 yr^{-1}
^{154}Eu	Periodicity: 1 yr^{-1}
^{222}Rn[c]	Periodicity: 1 yr^{-1}, 11.7 yr^{-1}, 2.1 yr^{-1}
^{226}Ra[c]	Periodicity: 1 yr^{-1}, 11.7 yr^{-1}, 2.1 yr^{-1}
^{239}Pu	Periodicity: 1/d, 13.5 yr^{-1}, 1 yr^{-1}

Prominent 1yr & 28da Periodicities

Studying this phenomena is of practical as well as scientific value…

CCHEN Decay Experiment:
Present Status

Mimic IMS Calibration Measurements but at Higher Data Rates & Longer Integration Times

Variety of Detectors & Sources

- ^{54}Mn, ^{36}Cl, ^{90}Sr, ^{32}Si
- Empty Detectors as Control
- Monitor Environmental Variables (TPH)

Coordinated w/ 4 Additional Sites

- CCHEN (Santiago, Chile)
- US Air Force Academy
- Purdue University
- Brigham Young University

Now Completing Final Report

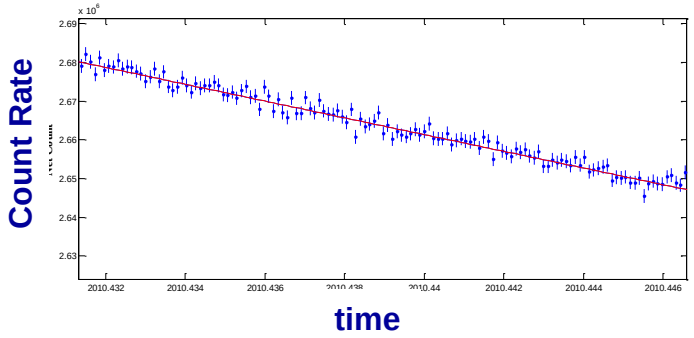
View of Test Chamber (top), Gieger Mueller and NaI Detectors (bottom right), and empty NaI detector in separate chamber,

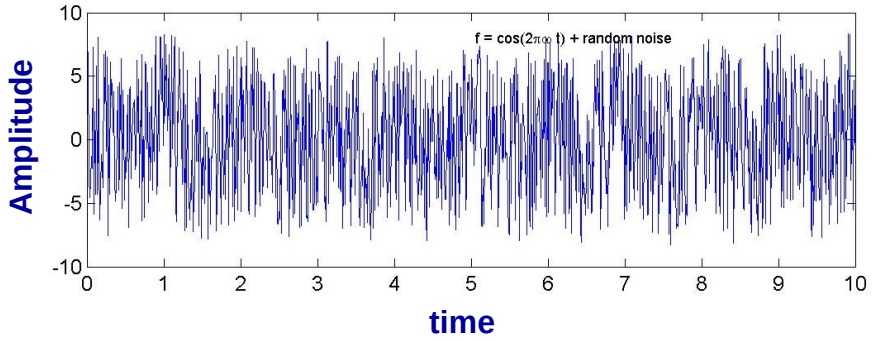
Six Detector Array: 4 Isotopes + 2 Empty

First 12 Months of Data Show Oscillations in Several Detectors

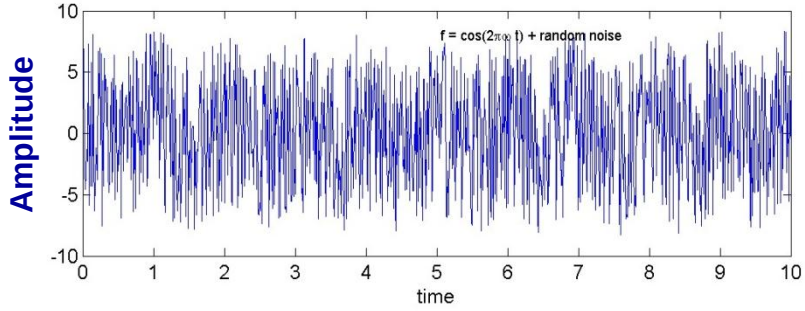
Analysis Methodology

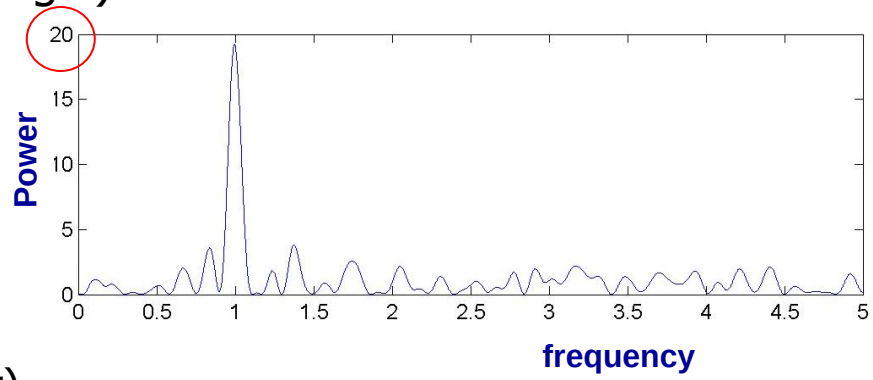
1) Determination of Residuals from Fit



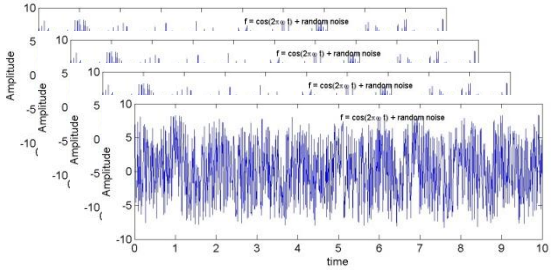


2) Spectral Analysis (modified Lomb-Scargle)

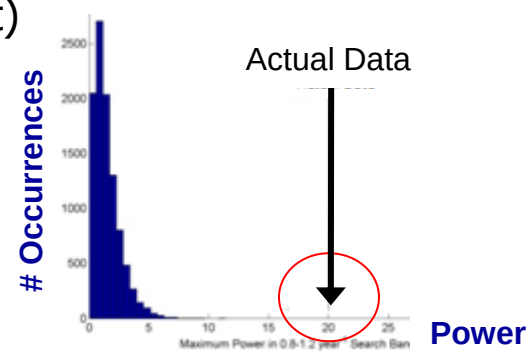




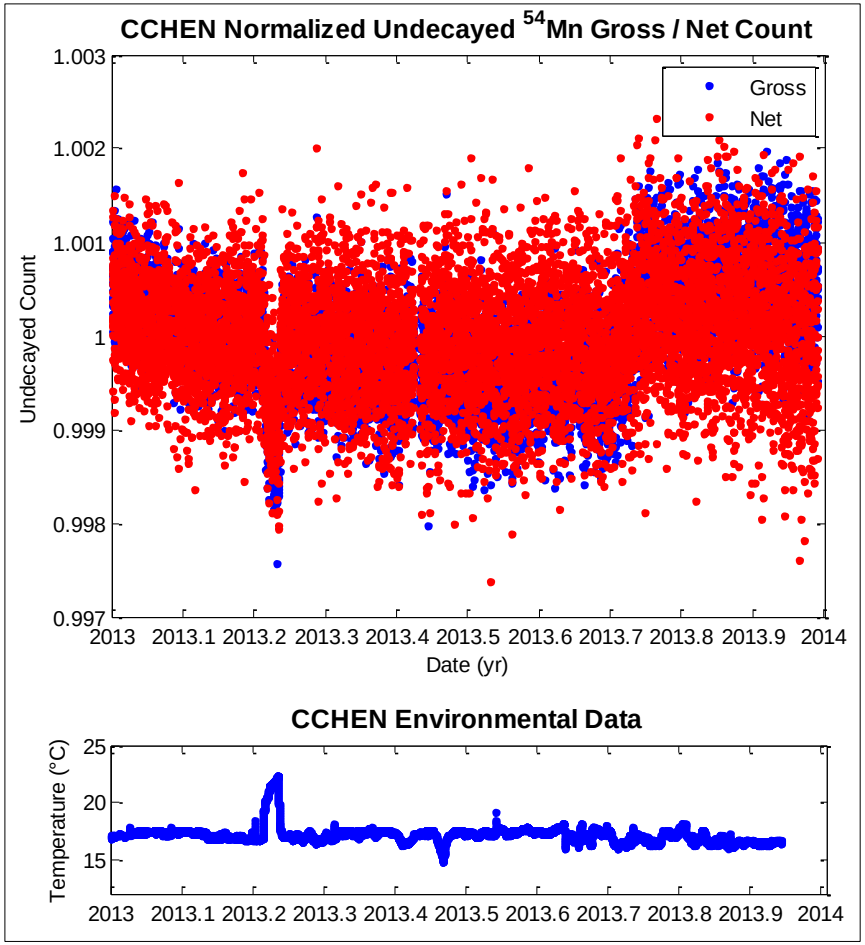
3) Significance Estimates (Shuffle Test)

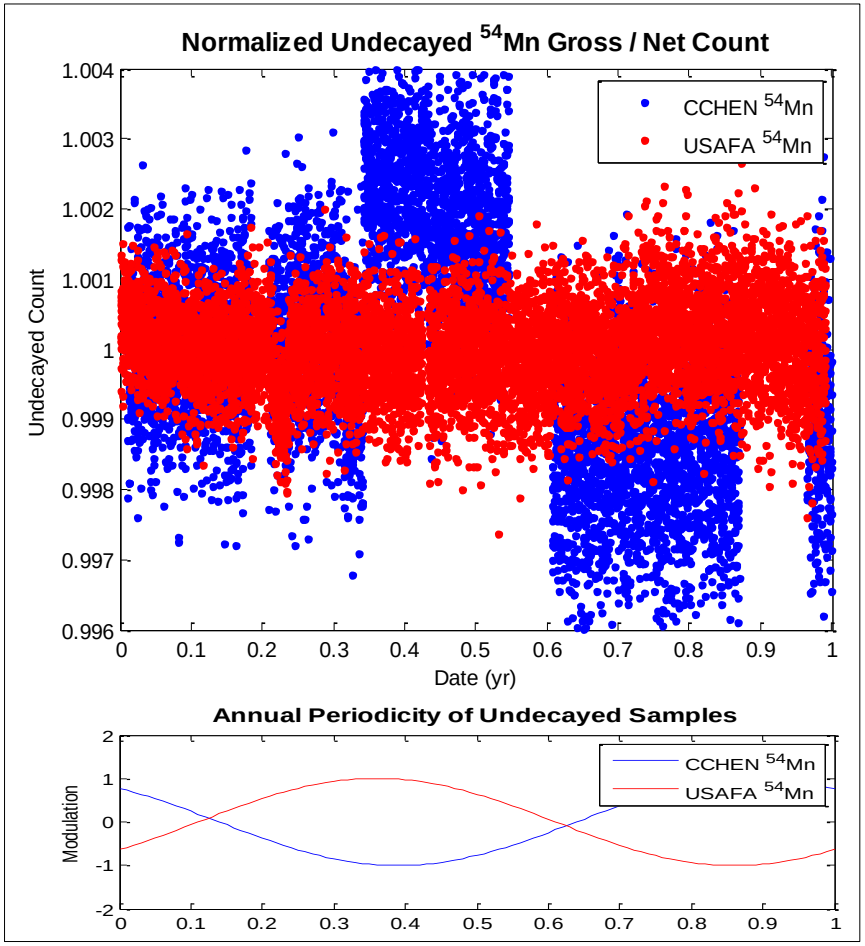


10,000 shuffled trials



Recent Results

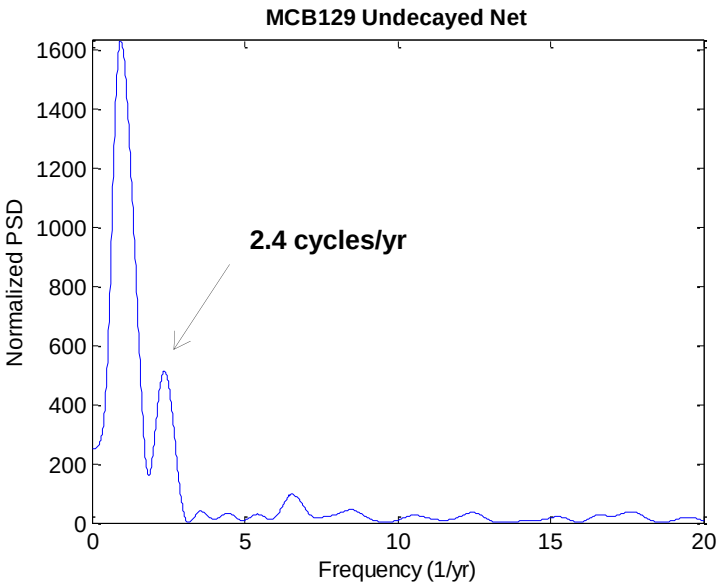


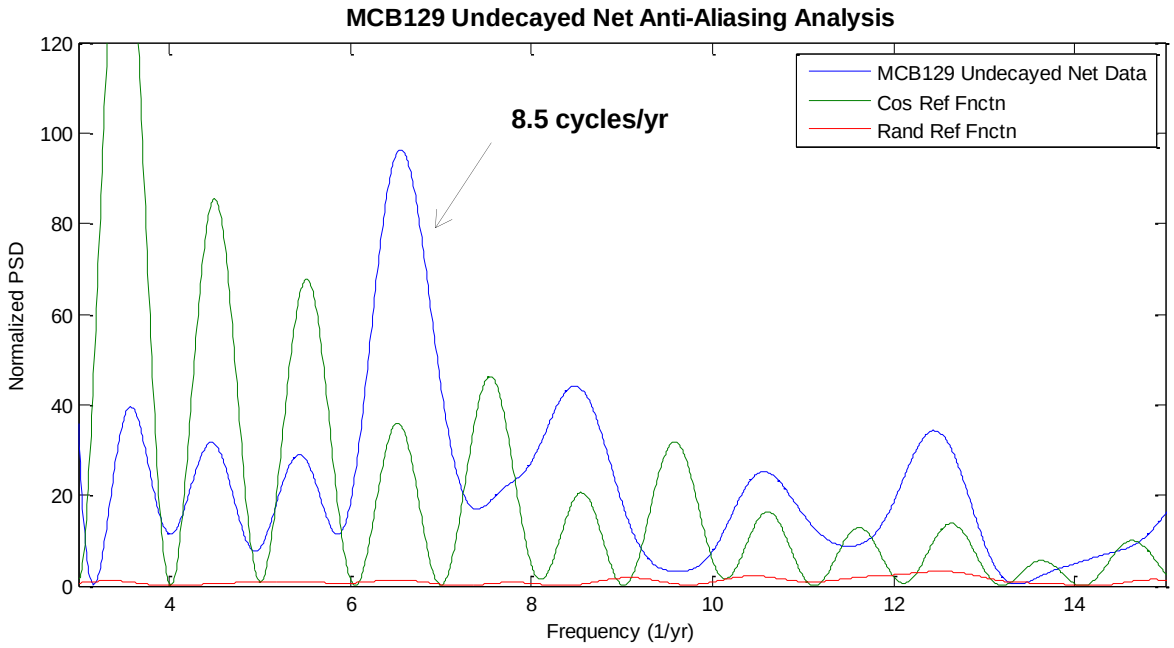


Analysis is well underway with focus on cross-comparisons between locations and autocorrelation with environmental factors (phase is complicated!)

Preliminary Results Indicate Phase Shifts Between Locations…

Recent Results





- **Oscillations have different phase than TPH measurements**
  - **Possibly a lag in NaI(d) response**
- **Empty detector shows null response**
- **No corresponding oscillations in GM Detectors**

Preliminary Results Indicate Several Non-Random Secondary Peaks…

Transition Approach

Direct Beneficiaries

Time-Series Analysis of Nuclear Decay Residuals Boosts Measurement Capabilities and Diagnostic Power

- **Comprehensive Test Ban Treaty Org. (CTBTO)**
- **AFTAC**
- **DTRA**
- **MDA**
- **Laboratori Nazionali del Gran Sasso**
- **Other Gov't Agencies**

Papers / Presentations

10 Peer-Reviewed Papers (2012-14)

Time-Varying Nuclear Decay Parameters and Dark Matter. In Review. 2014.

Power-Spectrum Analysis of Reconstructed DAMA Data. In Review. 2014

Concerning Time Dep. of Decay Rate… Applied Rad & Isotopes. 2013.

Stability of the IMS Radionuclide Detector Network. CTBTO SnT Conference. 2013.

+ 5 Recent Conference Presentations
+ Invited Book Chapter

Adoption of Methodology and Approach Is Growing Rapidly!